



SMB workload performance comparison: Dell™ PowerEdge™ T410 vs. HP ProLiant ML150 G6

Executive summary

Dell Inc. (Dell) commissioned Principled Technologies (PT) to measure the performance of the following servers running a typical small- to medium business (SMB) workload:

- Dell™ PowerEdge™ T410
- HP ProLiant ML150 G6

We simultaneously ran workloads that exercised three of the functions a typical small business server may have to handle: Web, email, and database services. We used WebBench to simulate Web traffic, Microsoft Exchange Load Generator (LoadGen) to simulate email activity, and DVD Store Version 2 (DS2) to simulate database activity. The Workload section provides more information on the benchmarks.

Figure 1 presents averaged results for the two servers on Windows Server 2008 x64 running the three workloads relative to the lower-performing server, the HP ProLiant ML150 G6. For each workload, we assigned a value of 100 percent to that server's results and then calculated the percentage performance improvement of the Dell PowerEdge T410. This approach makes each data point a comparative number, with higher numbers indicating better performance. Finally, we took the percentage performance improvement over the HP ProLiant ML150 G6 for the three benchmarks and averaged them.

KEY FINDINGS

- In competitive tests running email, database, and Web workloads simultaneously, the Dell PowerEdge T410 delivered better performance while consuming lower power and costing less than a comparably configured HP ProLiant ML150 G6.
- The Dell PowerEdge T410 cost \$1,000 less than the HP ProLiant ML150 G6, a 13% price savings.* (See Figure 12.)
- The Dell PowerEdge T410 delivered an average performance about 11% greater than the HP ProLiant ML150 G6, with much faster email response time (39% Dell advantage) and very slightly lower Web (1% HP advantage) and database (3% HP advantage) performance.* (See Figure 1.)
- The Dell PowerEdge T410 had lower power usage than the HP ProLiant ML150 G6 both when idle (18% Dell advantage) and under peak load (4% Dell advantage).* (See Figure 10.)
- The Dell PowerEdge T410 had a 16% performance/watt advantage over the HP ProLiant ML150 G6.* (See Figure 3.)
- The Dell PowerEdge T410 delivered a 27% performance/dollar advantage over the HP ProLiant ML 150 G6.* (See Figure 2.)

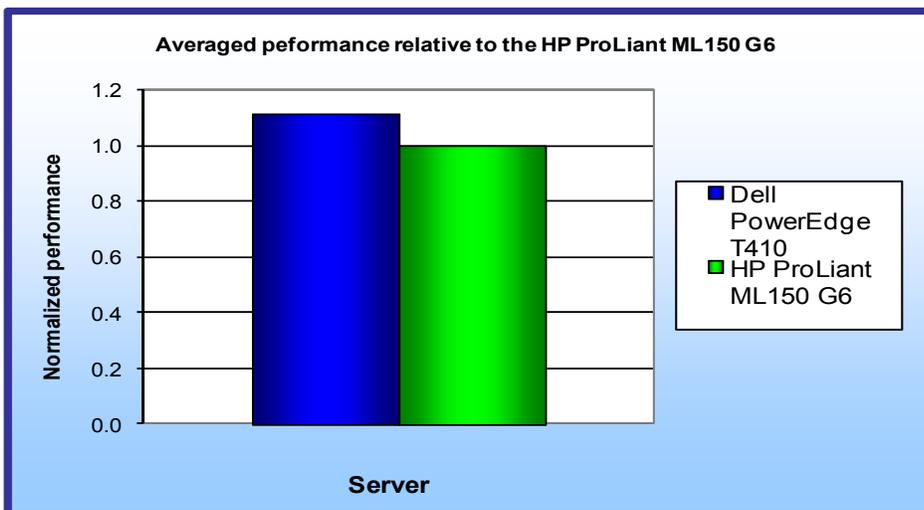


Figure 1: Averaged performance of the test servers running Windows Server 2008 across the three benchmarks relative to the HP ProLiant ML150 G6. Higher numbers are better.

As Figure 1 illustrates, the Dell PowerEdge T410 running on Windows Server 2008 delivered an average of 11 percent greater performance across the three benchmarks than did the HP ProLiant ML150 G6, delivering 39 percent faster email response time, 1 percent lower Web performance, and 3 percent lower database performance than did the HP ProLiant ML150 G6. For each server, we then took the averaged relative performance results in Figure 1 and divided them

* Based on a report published by Principled Technologies, commissioned by Dell, "Performance Analysis: Dell PowerEdge T410 vs. HP ProLiant DL150 G6 solution," June 2009.

by the price. (See Appendix A.) For ease of comparison, we normalized those results to those of the HP ProLiant ML150 G6.

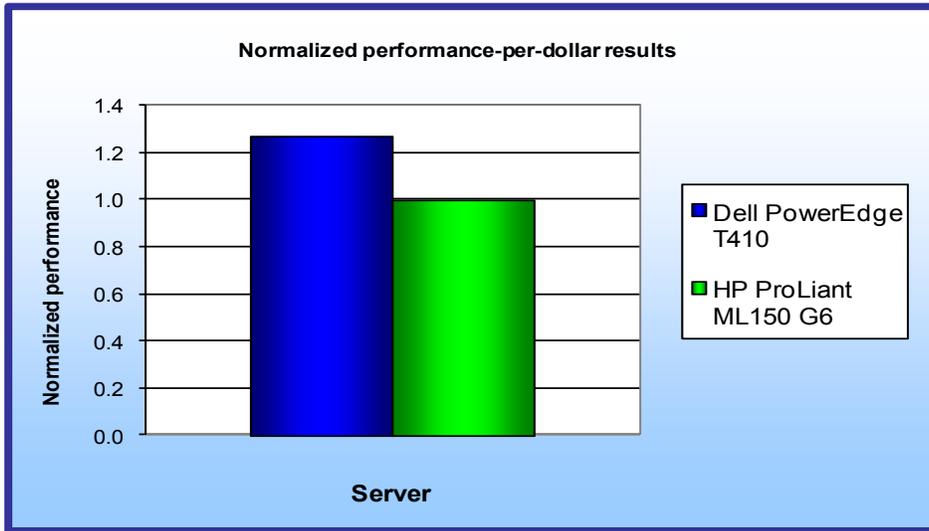


Figure 2: Normalized performance-per-dollar results of the test servers running Windows Server 2008 across the three benchmarks, relative to the HP ProLiant ML150 G6. Higher numbers are better.

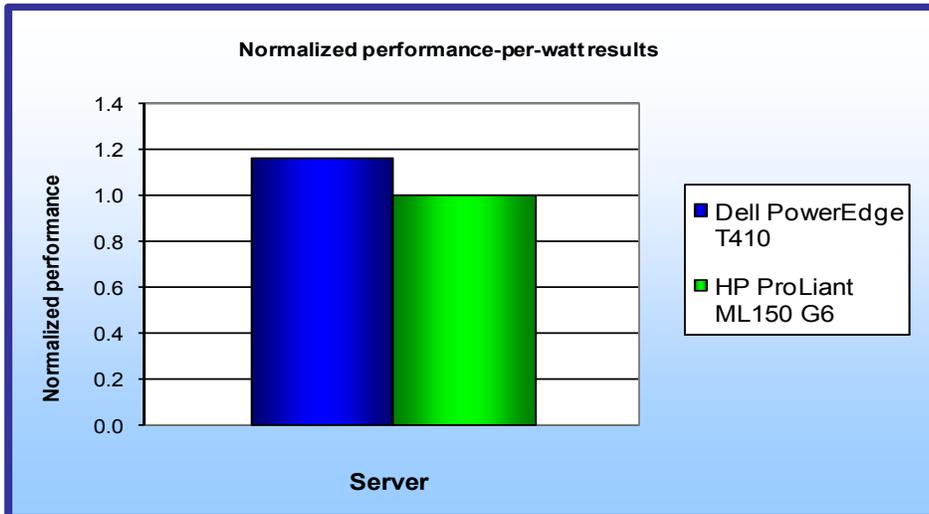


Figure 3: Normalized performance-per-watt results of the test servers running Windows Server 2008 across the three benchmarks, relative to the HP ProLiant ML150 G6. Higher numbers are better.

As Figure 2 illustrates, the Dell PowerEdge T410 produced a 27 percent higher performance-per-dollar result on Windows Server 2008 across the three workloads than did the HP ProLiant ML150 G6.

We also measured power consumption during the test. We took the averaged relative performance results in Figure 1 and divided them by the active power consumption. We normalized those results to those of the HP ProLiant ML150 G6.

As Figure 3 illustrates, the Dell PowerEdge T410 delivered a 16 percent better performance-per-watt result on Windows Server 2008 across the three workloads than did the HP ProLiant ML150 G6.

Workload

We ran the following three workloads simultaneously, as a typical small business server might.

WebBench

WebBench 5.0 (128-bit US version) is an industry-standard benchmark for Web server software and hardware. It uses PC clients to send Web requests to a server under test. It generates performance results by incrementally increasing the

number of clients making HTTP 1.0 GET requests to the Web server; the result is a curve showing the server's performance under increasing load. The peak of that curve represents the peak throughput of the server. WebBench reports both the total number of requests per second the server handled and the server's total throughput in bytes per second.

We ran the WebBench e-commerce CGI test suite for 45 minutes on both the Dell PowerEdge T410 and the HP ProLiant ML150 G6.

For more details about WebBench, see <http://home.tiscali.cz:8080/~cz210552/webbench.html>.

DVD Store

DVD Store Version 2 is an open-source application with a back-end database component, a front-end Web application layer, and a driver layer that operates as the middle tier and actually executes the workload.

Because our goal was to isolate and test database server and storage, we did not use the Web application layer. Instead, we ran the driver application on a client machine directly via its command-line interface.

DS2 models an online DVD store. Simulated customers log in; browse movies by actor, title, or category; and purchase movies. The workload also creates new customers. Browsing movies involves select operations, some of which use SQL Server 2008 full-text search and some of which do not. The purchase, login, and new customer stored procedures involve update and insert statements, as well as select statements. The workload's main reporting metric is orders per minute (OPM).

For the client machine, we used a desktop class system running Windows Server 2003 Enterprise Edition x86. The client machine ran a single instance of DS2, which spawned 125 threads, with three seconds of think time, and 10 searches per order. This simulated a realistic business environment. We used the default DS2 parameters and setup configuration, with the exceptions we note above and in the DVD Store setup section in the Test methodology section of this report.

The DS2 driver application creates an orders-per-minute performance counter on the client machine. While the DVD Store client application visually outputs OPM at 10-second intervals, we chose to collect this OPM metric via a performance monitor counter on each client machine at 1-second intervals.

We ran this workload for 40 minutes on both the Dell PowerEdge T410 and the HP ProLiant ML150 G6.

For more details about the DS2 tool, see <http://www.delltechcenter.com/page/DVD+Store>.

LoadGen

LoadGen is an industry-standard tool for benchmarking an Exchange 2007 Mail Server. LoadGen performs tasks to simulate a standard user generating mail activity. When the workload finishes, LoadGen reports the response time, which is the number of seconds necessary to complete the task.

Our goal was to compare the Microsoft Exchange Server 2007 response time of the Dell PowerEdge T410 Server to that of the HP ProLiant ML150 G6 Server.

Microsoft Exchange Load Generator is a simulation tool that measures the impact that various clients (MAPI, OWA, IMAP, POP, and SMTP) have on Exchange servers. This allows users to test how effectively a server running Exchange responds to e-mail loads. The simulator sends multiple message requests to the server running Exchange, resulting in a mail load.

We ran the Microsoft Exchange Load Generator benchmark for 30 minutes on both the Dell PowerEdge T410 and the HP ProLiant ML150 G6.

For more details about LoadGen, see <http://www.microsoft.com/downloads/details.aspx?FamilyId=DDEC1642-F6E3-4D66-A82F-8D3062C6FA98&displaylang=en>.

Test results

We staggered the starting times of the benchmarks to allow each server to ramp up slowly. We began the benchmarks in the following order: WebBench, DVD Store, and LoadGen. Figure 4 shows a timeline for the benchmark runs. To obtain the final results, we removed the first parts of the WebBench and DVD Store runs, and computed the results based on the 30 minutes of peak performance during the LoadGen run.

To make sure both servers achieved their optimum results, we allowed them to sit idle for 10 minutes before starting the workload.

Multiple benchmark timeline 45 minutes total time

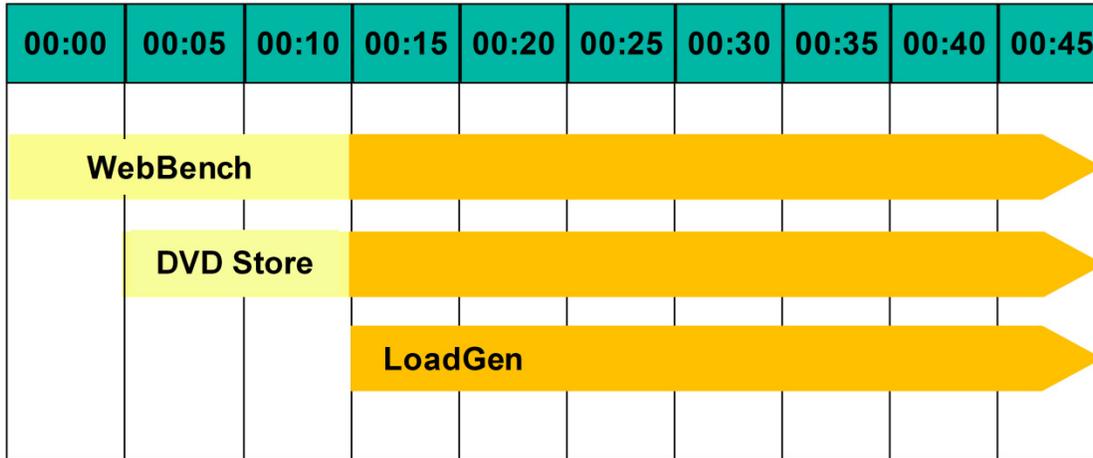


Figure 4: The timeline we followed when starting the benchmarks for the multiple-benchmark runs on both servers. The shaded areas from 00:15 to 00:45 represent the period during which we measured performance.

Figure 5 presents results for the servers on the three benchmarks relative to the lower-performing server, the HP ProLiant ML150 G6. For each benchmark, we assigned a value of 100 percent to that server’s results and then calculated the percentage performance improvement of the Dell PowerEdge T410. This approach makes each data point a comparative number, with higher numbers indicating better performance. Finally, we took the percentage performance improvement over the HP ProLiant ML150 G6 for the three benchmarks and averaged them.

As Figure 5 shows, the Dell PowerEdge T410 running Windows Server 2008 achieved better performance on all benchmarks than did the HP ProLiant ML150 G6. Each result is the median of three runs. With the exception of CPU utilization, all results are relative to the HP ProLiant ML150 G6. We used LoadGen to determine the median for all runs.

Server	Percentage CPU utilization	Web requests per second (relative to HP ProLiant ML150 G6)	Email response time (relative to HP ProLiant ML150 G6)	Orders per minute (relative to HP ProLiant ML150 G6)	Average of Web, email, and database scores (relative to HP ProLiant ML150 G6)
Dell PowerEdge T410	58.80	0.99	1.39	0.97	1.11
HP ProLiant ML150 G6	63.10	1.00	1.00	1.00	1.00

Figure 5: Performance for the servers on the three benchmarks, relative to the HP ProLiant ML150 G6. Higher numbers are better.

WebBench results

We ran WebBench’s default e-commerce CGI test suite, which generates both secure and non-secure static and dynamic HTTP 1.0 GET requests. While running the e-commerce suite, the clients must negotiate to a secure Web server port using the Secure Socket Layer (SSL) protocol. A default WebBench test suite incrementally increases the number of clients making the HTTP 1.0 GET requests to the Web server. As the workload increases the number of clients, the Web server’s processor utilization also increases, until the clients saturate the processor in the Web server with work. Each workload point with a fixed number of clients is a WebBench “mix.” The e-commerce CGI test suite begins with a mix that involves one client; the next mix involves four clients;

and each subsequent mix increases the number of clients by four. We modified the test suite so it would run 40 clients, with 10 engines per client for the entire test. This allowed us to keep a constant Web load on the server. To limit the amount of time WebBench ran, we performed only nine mixes for testing.

A WebBench run reports the total requests per second a server can perform and the total throughput, in bytes per second, that the server delivered. WebBench reports these results for each mix. To obtain the results we list in Figure 6, we averaged the requests per second and throughput from the mixes that ran during the peak performance of the benchmark run, as Figure 4 illustrates.

Figure 6 shows the WebBench peak results in requests per second and in throughput (bytes per second) for the test servers. Each result is the median of three runs.

Server	Throughput (bytes per second)	Requests per second (raw)	Requests per second (relative to HP ProLiant ML150 G6)
Dell PowerEdge T410	437,793,554.06	44,826.32	0.99
HP ProLiant ML150 G6	444,106,460.56	45,501.19	1.00

Figure 6: Median WebBench results for the two servers. Higher numbers are better.

DVD Store results

Figure 7 shows the number of OPM each solution achieved during our measurement period of the DVD Store test on the median run. We calculated the scores by averaging the OPM during the 30-minute period.

Server	Orders per minute	Orders per minute (relative to HP ProLiant ML150 G6)
Dell PowerEdge T410	2,408.60	0.97
HP ProLiant ML150 G6	2,482.50	1.00

Figure 7: Median DVD Store results for the two servers. Lower response time is better.

LoadGen results

LoadGen results show the response time each for each server, which is the time in milliseconds it took to complete a request. Because the object of the server is to handle as many requests as possible, lower scores, which show a server able to handle more requests in a given time, are better.

For testing, we used 125 Microsoft Exchange mailboxes; both servers could handle the load while performing other tasks. Figure 8 shows the average response time for both servers. Each result is the median of three runs.

Server	Average response time (in seconds)	Median 95th percentile (relative to HP ProLiant ML150 G6)
Dell PowerEdge T410	391.15	1.39
HP ProLiant ML150 G6	639.18	1.00

Figure 8: Median LoadGen results for the two servers. Lower response time is better.

Because the results are in response time for each task, we created a weighted average to calculate a final score. To create a weighted average, we used a similar procedure as the one that Microsoft Exchange Server 2003 Load Simulator (LoadSim) uses. (Note: LoadSim is an older tool for testing Exchange Mail Servers; Microsoft has replaced it with LoadGen.) Figure 9 shows the weighted average we used for testing.

Task name	Weight	Task name	Weight
BrowseCalendar	1	BrowseContacts	0
Logon	0	CreateContact	0
Logoff	0	BrowseTasks	0
SendMail	1	CreateTask	0
ReadAndProcessMessages	50	EditRules	2
MoveMail	0	DownloadOab	0
DeleteMail	0	EditSmartFolders	2
ExportMail	0	SynchronizeFolders	0
CreateFolder	0	Search	0
PublicFolderPost	0	InitializeMailbox	0
BrowsePublicFolder	0	UserInit	0
PostFreeBusy	2	UserTerm	0
RequestMeeting	1	ModuleInit	0
MakeAppointment	1	ModuleTerm	0
Total			60

Figure 9: Weighted average for LoadGen tasks.

Figure 10 shows the power results during the median run of the Dell PowerEdge T410 and HP ProLiant ML150 G6. Lower numbers are better.

Server	Idle power	Workload power
Dell PowerEdge T410	205.21	319.75
HP ProLiant ML150 G6	249.30	333.20

Figure 10: Average idle and workload power results, in watts, for the two servers during the median run. Lower numbers are better.

To calculate the power, we average the power we recorded during our workload measurement period. For the idle power, we allowed the system to sit for 10 minutes after booting to the desktop and then started 2 minutes of idle power capture.

Test methodology

Figure 11 summarizes some key aspects of the configurations of the two server systems; Appendix B provides detailed configuration information.

Server	Dell PowerEdge T410	HP ProLiant ML150 G6
Processor	Intel Xeon E5540	Intel Xeon E5540
Processor frequency (GHz)	2.53	2.53
RAM (24 GB in each)	6 x 4 GB PC3-10600	6 x 4 GB PC3-10600
Hard drive	6 x 146 GB, 15,000 rpm, SAS	6 x 146 GB, 15,000 rpm, SAS
NICs	Broadcom BCM5716C NetXtreme II Adapter (integrated), Intel PRO/1000 PT Quad Port Server Adapter (PCI-Express)	HP NC107i Integrated PCI Express Gigabit Server Adapter (Integrated), HP NC364T PCI Express Quad Port Gigabit Server Adapter (PCI-Express)
Total system fans	1	4

Figure 11: Key aspects of the server configurations.

Dell provided the Dell PowerEdge T410 for testing. PT purchased the HP ProLiant ML150 G6. PT configured both servers (with Dell's approval), and made sure they were comparable configurations.

Note: The Dell PowerEdge T410 only comes with one system fan. The HP ProLiant ML150 G6 comes with two fans in the single processor configuration. When we installed the second processor, the HP ProLiant ML150 G6 posted an error message stating an additional fan is required. We had to install the HP 5U G6 Redundant fan kit to get the system to boot without errors in the two-processor configuration.

For testing, we configured the six SAS hard drives into two RAID volumes. We configured the first volume as a two disk RAID 1, which we installed the OS on. We configured the second volume as a four disk RAID 5 for the SQL database and Microsoft Exchange 2003 Mailstore.

Installing and configuring the OS

We began our testing by installing a fresh copy of Windows Server 2008, Enterprise x64 Edition on each server. We followed this process for each installation:

1. At the Language Selection Screen, click Next.
2. Click Install Now.
3. Select Windows Server 2008 Enterprise (Full Installation) x64, and click Next.
4. Click the I accept the license agreement check box, and click Next.
5. Click Custom.
6. Click Next.
7. At the warning that the user's password must be changed before entering the OS, click OK.
8. Type `Password1` as the new password.
9. At the Your password has been changed screen, click OK.

Installing system updates

We installed the following updates using Microsoft Windows update feature:

- Security Update for Windows Server 2008 x64 Edition (KB961063)
- Security Update for Windows Server 2008 x64 Edition (KB949014)
- Hotfix for Windows (KB942288)
- Microsoft .NET Framework 3.5 Service Pack 1 and .NET Framework 3.5 Family Update (KB951847)
- Security Update for Windows Server 2008 x64 Edition (KB958687)
- Update for Windows Server 2008 x64 Edition (KB957388)
- Security Update for Windows Server 2008 x64-based Systems (KB938464)
- Update for Windows Server 2008 x64 Edition (KB949189)
- Security Update for Windows Server 2008 x64 Edition (KB955069)
- Security Update for Windows Server 2008 x64 Edition (KB954459)
- Security Update for Windows Server 2008 x64 Edition (KB957097)
- Security Update for Windows Server 2008 x64 Edition (KB958690)
- Cumulative Security Update for Internet Explorer 7 for Windows Server 2008 x64 Edition (KB963027)
- Security Update for Windows Server 2008 x64 Edition (KB960803)
- Internet Explorer 8 for Windows Server 2008 x64 Edition
- Security Update for Windows Server 2008 x64 Edition (KB958623)
- Update for Windows Server 2008 x64 Edition (KB959130)
- Windows Malicious Software Removal Tool x64 – May 2009 (KB890830)
- Update for Windows Server 2008 x64 Edition (KB957200)
- Security Update for Windows Server 2008 x64 Edition (KB953733)
- Security Update for Windows Server 2008 x64 Edition (KB950762)
- Update for Windows Server 2008 x64 Edition (KB955839)
- Security Update for Windows Server 2008 x64 Edition (KB958624)
- Security Update for Windows Server 2008 x64 Edition (KB950974)
- Update for Windows Server 2008 x64 Edition (KB951978)
- Update for Windows Server 2008 for x64-based Systems (KB955020)
- Security Update for Windows Server 2008 x64 Edition (KB956572)

- Security Update for Windows Mail for Windows Server 2008 x64 Edition (KB951066)
- Update Rollup for ActiveX Killbits for Windows Server 2008 x64 Edition (KB960715)
- Security Update for Windows Server 2008 x64 Edition (KB960225)
- Security Update for Windows Server 2008 x64 Edition (KB956802)
- Update for Windows Server 2008 x64 Edition (KB957321)
- Update for Windows Server 2008 x64 Edition (KB952287)
- Security Update for Windows Server 2008 x64 Edition (KB958644)
- Security Update for Windows Server 2008 x64 Edition (KB959426)
- Security Update for Windows Server 2008 x64 Edition (KB952004)
- Security Update for Windows Server 2008 x64 Edition (KB951698)
- Update for Windows Server 2008 x64 Edition (KB950050)
- Cumulative Security Update for ActiveX Killbits for Windows Server 2008 x64 Edition (KB950760)
- Update for Windows Server 2008 x64 Edition (KB955302)
- Windows Update Agent 7.2.6001.788

General OS settings

1. Open the control panel.
2. Double-click User Accounts.
3. Click Turn User Account Control on or off.
4. Beside Use User Account Control (UAC), uncheck the check box.
5. Reboot the system.

Installing and configuring the mail server

Setting up the Active Directory

1. Click Start→Administrative Tools→Server Manager.
2. Click Roles on the left-side windowpane.
3. Click Add Roles.
4. Click the Skip this page by default check box, and click Next.
5. Click the Active Directory Domain Services check box, and click Next.
6. Click Next.
7. Click Install.
8. Click Close.

Assigning static IPs to the NICs

1. Click Start→Network.
2. Click Network and Sharing Center.
3. Click Manage Network Connections.
4. Right-click Local Area Connection.
5. Click Properties.
6. Click Internet Protocol Version 4 (TCP/IPv4), and click Properties.
7. Select Use the following IP Address, and input the following numbers:
 IP Address: 192.168.1.1
 Subnet mask: 255.255.255.0
8. Repeat steps 4 through 7 for Local Area Connection 2 and Local Area Connection 3 using the following IP information for each:
 Local Area Connection 2:
 IP Address: 10.1.1.250
 Subnet mask: 255.255.255.0
 Local Area Connection 3:
 IP Address: 10.1.2.250
 Subnet mask: 255.255.255.0

Setting up the domain

1. Click Start, type `cmd` in the prompt, and press Enter.
2. Type `dcpromo`, and press Enter.
3. Click Next.
4. Click Next.
5. Click Next.
6. Select Create a new domain in a new forest, and click Next.
7. Type `test.lan` as the FQDN (Fully Qualified Domain Name), and click Next.
8. Set the forest functional level to Windows Server 2003, and click Next.
9. Set the domain functional level to Windows Server 2003, and click Next.
10. Leave defaults on the Additional Domain Controller Options screen, and click Next.
11. If a warning window appears asking about dynamically assigned IP addresses, click Yes.
12. Click Yes to continue.
13. Leave defaults at the Location for Database, Log Files, and SYSVOL screen; and click Next.
14. At the Directory Services Restore Mode Administrator Password screen, type `Password1`
15. At the summary screen, click Next.
16. Click Finish.
17. Click Restart now.

Setting up the Application Server

1. Click Start→Administrative Tools→Server Manager.
2. Click Roles on the left-side window pane.
3. Click Add Roles.
4. Click the Application Server check box.
5. When the Add features required for Application Server? screen appears, click Add Required Features.
6. Click Next.
7. Click Next
8. At the Select Role Services page for Application Server, click the Web Server (IIS) Support check box.
9. When the Add features required for Web Server (IIS) Support? screen appears, click Add Required Features.
10. Click Next.
11. Click Next.
12. At the Select Role Services page for Web Server (IIS), click IIS 6 Management Compatibility, ASP, and CGI check boxes; and click Next.
13. Click Install.
14. Click Close.

Installing Microsoft Exchange

1. Click Start→Administrative Tools→Server Manager.
2. Click Features.
3. Click Add Features.
4. Select the Windows PowerShell check box, and select Next.
5. Click Install.
6. Click Close.
7. Run Exchange 2007 SP1 `install.exe`.
8. In the choose directory for extracted files text prompt, type `C:\exc`
9. Click OK.
10. Click OK.
11. In the `C:\exc` folder, double-click `setup.exe`.
12. Click Step 4: Install Microsoft Exchange Server 2007 SP1.
13. Click Next.
14. Accept the License agreement, and click Next.
15. Click Next.
16. Select Typical Exchange Server installation, and click Next.
17. At the Exchange organization screen, click Next.

18. At the Client settings screen, click Next.
19. After the system finishes the readiness check, click Install.
20. Click Finish.
21. Click OK.
22. Restart the system.

Enabling Circular Logging

1. Click Start→All Programs→Microsoft Exchange Server 2007→Exchange Management Console.
2. Expand Server Configuration, and click Mailbox.
3. Right-click First Storage Group, and click Properties.
4. Check the box beside Enable circular logging, and click OK.

Disabling Maintenance Schedule

1. Click Start→All Programs→Microsoft Exchange Server 2007→Exchange Management Console.
2. Expand Server Configuration, and click Mailbox.
3. Right-click Mailbox Database, and click Properties.
4. Click Customize.
5. Double-click the empty gray box above Sunday.
6. Ensure that all cells on the graph turn white, and click OK.
7. Click OK.

Installing and configuring the Web server (WebBench)

Deploying WebBench data

WebBench includes data that must reside on the server and that the Web server must use. We used the following procedure to load that data and set the Web server to use it:

1. Copy the file wbtrees.exe from the WebBench CD to the wwwroot directory on the server under test. (The wbtrees.exe file is on the WebBench CD at \wb50\workload. The wwwroot directory is located at C:\inetpub\wwwroot.)
2. On the server, execute the wbtrees.exe file. This program copies the WebBench workload to the server.
3. In the wwwroot folder on the server, create a new folder with the name CGI-BIN
4. Copy the file simcgi.exe to the CGI-BIN folder.
5. Click Start→Programs→Administrative Tools→Computer Management to open the management console.
6. Go to Services and Applications→Internet Information Services (IIS) Manager→ServerName.
7. Double-click ISAPI and CGI Restrictions.
8. Click Add.
9. Enter the path for the simcgi.exe, and click the Allow extension path to execute check box.
10. Click OK.

Configuring Internet Information Services (IIS)

We configured the Windows Internet Information Services Web server as follows:

1. Open Computer Management.
2. Go to Services and Applications→Internet Information Services (IIS) Manager→ServerName.
3. Double-click MIME Types.
4. In the MIME Types window, click Add.
5. In the Extension field, type *.
6. In the MIME Type field, type application/octet-stream, and click OK.
7. Double-click the server name on the left side of the window.
8. Double-click ISAPI and CGI Restrictions.
9. Click Edit Feature Settings.
10. Click the check boxes beside Allow unspecified CGI module and Allow unspecified ISAPI modules.
11. Click OK.
12. Go to Services and Applications→Internet Information Services (IIS) Manager→ServerName.
13. Double-click Logging.
14. Click Disable.

Installing certificate services

Because WebBench includes tests that involve security, we installed Windows Certificate Services as follows:

1. Go to Services and Applications→Internet Information Services (IIS) Manager→ServerName.
2. Double-click Server Certificates.
3. Click Create Self-Signed Certificate.
4. Name it Performance and click OK.
5. Go to Services and Application→Internet Information Services (IIS) Manager→ServerName→Sites→Default Web Site.
6. Click Bindings...
7. Click the https entry, and click Edit.
8. Set the SSL Certificate to Performance, and click OK.
9. Click Add.
10. Set the type to http, and set the IP address to 192.168.1.1
11. Set the Port to 81 and click OK.
12. Click Add.
13. Set the type to https, and set the IP address to 192.168.1.1
14. Set the SSL Certificate to Microsoft Exchange.
15. Set the Port to 444 and click OK.
16. If a warning window pops up, click Yes.
17. Click Close.
18. Double-click SSL settings.
19. Uncheck the Require SSL check box.
20. Click Apply.

Creating SSL Communication

We enabled SSL communication as follows:

1. Go to Services and Applications→Internet Information Services (IIS) Manager→ServerName.
2. Expand the Default Web site.
3. Expand wbtrees.
4. Click Wbssl.
5. Double-click SSL Settings.
6. Check Require SSL.
7. Check Require 128-bit SSL.
8. Click Apply.

We then set the following operating system tuning parameters for optimum WebBench performance. When creating the following parameters, ensure that they are DWORD files, with decimal coding (rather than hexadecimal):

- HKLM\System\CurrentControlSet\Services\Inetinfo\Parameters\MaxCachesFileSize to 1048576
- HKLM\System\CurrentControlSet\Services\HTTP\Parameters\UriMaxUriBytes to 1048576
- HKLM\System\CurrentControlSet\Control\FileSystem\NtfsDisableLastAccess to 1
- HKLM\System\CurrentControlSet\Services\Tcpip\Parameters\MaxHashTableSize to 65535

Installing SQL Server 2008 on the server

1. Insert the DVD into the physical DVD drive.
2. At the AutoPlay menu, click Run SETUP.EXE.
3. If the application prompts you to install the .NET Framework, click OK.
4. Select the Accept radio button, and click Install.
5. When the installation finishes, click Exit.
6. If the application prompts you, click OK to install a hotfix for Windows (KB942288).
7. Click Restart now to restart the server upon completion.
8. After rebooting, log into the server.
9. Click Start, and click Computer.
10. Double-click the CD/DVD drive.
11. Click Installation.

12. Click New SQL Server stand-alone installation.
13. On the Setup support rules screen, click OK.
14. Specify the Enterprise Evaluation free edition. Click Next.
15. Click the checkbox to accept the license terms. Click Next.
16. Click Install to install the setup support files.
17. You may see a Computer domain controller warning and a Windows Firewall warning. For now, ignore this, and click Next.
18. On the Feature Selection screen, select Database Engine Services, Full-Text Search, Client Tools Connectivity, Client Tools Backward Compatibility, Management Tools –Basic, and Management Tools – Complete. Click Next.
19. On the Instance configuration screen, leave the default selection of default instance, and click Next.
20. On the Disk space requirements screen, click Next.
21. On the Server configuration screen, choose NT AUTHORITY\SYSTEM for SQL Server Agent, and choose NT AUTHORITY\SYSTEM for SQL Server Database Engine. Click Next.
22. On the Database Engine Configuration screen, select Mixed Mode.
23. Enter a password for the system administrator account.
24. Click Add Current user. This may take several seconds.
25. Click Next.
26. On the Error and usage reporting screen, click Next.
27. On the Installation rules screen, click Next.
28. On the Ready to Install screen, click Next.
29. After installation completes, click Start, All Programs, Microsoft SQL Server 2008, Configuration Tools, SQL Server Configuration Manager.
30. Expand the Network Configuration node, and select the relevant instance.
31. In the right pane, right-click TCP/IP, and choose Enable.
32. In the left pane, click SQL Server Services.
33. In the right pane, right-click the relevant instance, and select Restart.
34. Click Start, Administrative Tools, and Local Security Policy.
35. In the left pane, expand Local Policies, and click User Rights Assignment.
36. In the right pane, double-click Perform Volume Maintenance Tasks, and add the System account.
37. Double-click Lock Pages in Memory, and add the System account.
38. Create a SQL Server login for the ds2user (see the DVD Store setup section below for the specific script to use).
39. Place the DVD Store backup file you prepared in the default location for SQL Server: C:\Program Files\Microsoft SQL Server\MSSQL10.MSSQLSERVER\MSSQL\Backup.

Installing SQL Server 2008 SP1

Service Pack 1 is available for download from

<http://www.microsoft.com/downloads/details.aspx?FamilyID=66ab3dbb-bf3e-4f46-9559-ccc6a4f9dc19&displaylang=en>.

1. Run SQLServer2008SP1-KB968369-x64-ENU.exe.
2. At the Welcome screen, click Next
3. At the License terms screen, accept the license terms, and click Next.
4. At the Features screen, select available features, and click Next.
5. At the Check files in use screen, wait for the installer to complete its check, and click Next.
6. At the Update screen, click Update.
7. When the update completes, click Next, and click Close.

Configuring additional drives in Disk Management

1. Click Start, Administrative Tools, Computer Management.
2. Click Disk Management.
3. Right-click the uninitialized disks (if any), and choose Initialize Disk.
4. Choose MBR.
5. Right-click the volume, and choose New Simple Volume. Click Next.
6. Keep the default drive space, and click Next.

7. Keep the default drive letter assignment, and click Next.
8. Choose NTFS, 64KB allocation unit size, and check the Perform a quick format checkbox. Click Next.
9. Click Finish.

Create the folders necessary for the database. We used <driveletter>:\SQLData for the SQL Server database volume and <driveletter>:\SQLLog for the SQL Server transaction log volume.

Installing and configuring the database server (DVD Store)

Data generation overview

We built the database schema using the scripts in the DS2 distribution package, though we made a few minor modifications. The DS2 stress tool provides options to generate 10MB, 1GB, or 100GB datasets. To get the tool to generate the 5 GB of user data we used in this test, we had to make a few straightforward changes to the source code and to the DVD Store application's scripts. Note: We created our test data on a Linux system to take advantage of the larger RAND MAX.

Editing the ds2_create_orders.c module

The module ds2_create_orders.c defines constants that define the maximum values for the customer ID and the product ID. The constants for the 5GB database size did not exist. We added the constants for this size.

On the command line for the ds2_create_orders.c module, we specified the size. The available options were S (small), M (medium), and L (large). We added the case V for the 5GB database. In the switch statement that sets the values for the variables max_cust_id and max_prod_id, we added cases that assigned them the proper values for the 5GB database size.

We recompiled the ds2_create_orders.c module on Linux, following the instructions in the header comments. We used the following command line:

```
gcc -o ds2_create_orders ds2_create_orders.c -lm
```

Editing the ds2_create_cust.c module

We had to make the same changes to the ds2_create_cust.c module that we made to the ds2_create_orders.c module. On the command line for the ds2_create_cust.c module, we specified the size. The available options were S (small), M (medium), and L (large). We added the case V for the 5GB database. In the switch statement that sets the values for the variables max_cust_id and max_prod_id, we added cases that assigned them the proper values for the 5GB database size.

We recompiled the ds2_create_cust.c module on Linux, following the instructions in the header comments. We used the following command line:

```
gcc -o ds2_create_cust ds2_create_cust.c -lm
```

Generating the data for the 5GB database

We used shell scripts to run all four of the executables that generate the data. The distribution did not include shell scripts for the 5GB size. We wrote shell scripts based on the ds2_create_cust_large.sh and ds2_create_orders_large.sh scripts. The ds2_create_prod and ds2_create_inv executables did not ship with associated shell scripts, so we created shell scripts using the instructions in the readme files. We ran the shell scripts in the following order to generate the data for the 5GB database:

1. ds2_create_orders_5gb.sh
2. ds2_create_inv_5gb.sh
3. ds2_create_prod_5gb.sh
4. ds2_create_cust_5gb.sh

We waited until the processes finished before we moved onto the next step.

Creating the database

We modified the database creation SQL Server scripts in the DVD Store distribution package to build the database schema, which includes the file structure, tables, indices, stored procedures, triggers, and so on. We built a master copy of the 5GB database version for SQL Server 2008, and then used that master copy to restore

our test database to the systems between each test run. We stored the backup file on the C: drive for quick access.

We followed these steps to create the database:

1. We created the database and file structure using database creation scripts in the DS2 download. We made size modifications specific to our 5GB database and the appropriate changes to drive letters.
2. We created database tables, stored procedures, and objects.
3. We set the database recovery model to bulk-logged to prevent excess logging.
4. We loaded the data we generated into the database. For data loading, we used the import wizard in SQL Server Management Studio. Where necessary, we retained options from the original scripts, such as Enable Identity Insert.
5. We created indices, full-text catalogs, primary keys, and foreign keys using the database-creation scripts.
6. We updated statistics on each table according to database-creation scripts, which sample 18 percent of the table data.
7. On the default SQL Server instance, we created a ds2user SQL Server login using the following Transact SQL (TSQL) script:

```
USE [master]
GO
CREATE LOGIN [ds2user] WITH PASSWORD=N'' ,
DEFAULT_DATABASE=[master] ,
DEFAULT_LANGUAGE=[us_english] ,
CHECK_EXPIRATION=OFF,
CHECK_POLICY=OFF
GO
```

8. We set the database recovery model back to full.

We made the following changes in the build scripts:

- Because we varied the size of the datasets, we sized the files in our scripts to reflect the database size and the number of files per filegroup. We allowed for approximately 40 percent free space in our database files to ensure that filegrowth activity did not occur during the testing.
- We followed Microsoft's recommendation of having 0.25 to 1 file per filegroup per core. The Intel Xeon Processor E5540 had eight cores with hyper-threading, or 16 logical processors. We used eight files per filegroup.
- We did not use the DBCC PINTABLE command for the CATEGORIES and PRODUCTS tables, both because Microsoft recommends against this practice and because the commands do nothing in SQL Server 2008.
- We added the FORCESEEK hint in the BROWSE_BY_ACTOR stored procedure because in initial testing we found that SQL Server 2008 was choosing an index scan instead of the preferred index seek, adding unnecessary overhead.
- We created a SQL Server login we called ds2user and mapped a database user to this login. We made each such user a member of the db_owner fixed database role.
- Using the DVD Store scripts as a reference, we created the full-text catalog and index on the PRODUCTS table manually in SQL Server Management Studio.

We then performed a full backup of the database. This backup allowed us to restore the databases to a pristine state relatively quickly between tests.

Editing the workload script - ds2xdriver.cs module

To use the 5GB database we created earlier, we had to change the following constants:

- In the routine Controller(), we changed the string sizes. We added the V option for the 5GB database size. DS2 uses the sizes string to interpret the db_size_str option.

- In the class Controller, we changed the arrays MAX_CUSTOMER and MAX_PRODUCT. To each, we added values specifying the bounds for the customer and product IDs. The Controller() routine uses these arrays.
- We added a command line parameter for the database name:

```
-database_name
```

Editing the workload script - ds2sqlserverfns.cs module

We changed the connection string to increase the number of available connections, to not use the default administrator ("sa") account, and to include a parameter for the database name. We raised the available connections limit from the default of 100 to 200 to allow room for experimentation. We created a user account we called ds2User and used that account.

The ds2connect routine in the ds2sqlserverfns.cs module defines sConnectionString. We used the following string; the changes we made appear in bold:

```
string sConnectionString = "User ID=ds2User;Initial Catalog=+" + dbname + "";Max  
Pool Size=200;Connection Timeout=120;Data Source=" + Controller.target;
```

Recompiling the ds2sqlserverdriver.exe executable

We recompiled the ds2xdriver.cs and ds2sqlserverfns.cs module in Windows by following the instructions in the header comments. Because the DS2 instructions were for compiling from the command line, we used the following steps:

1. Open a command prompt.
2. Use the cd command to change to the directory containing our sources.
3. Run the batch file C:\Program Files\Microsoft Visual Studio 9.0\Common7\Tools\vsvars32.bat. This sets up the environment variables for us.
4. Execute the following command:

```
csc /out:ds2sqlserverdriver.exe ds2xdriver.cs ds2sqlserverfns.cs  
/d:USE_WIN32_TIMER /d:GEN_PERF_CTRS
```

Installing the mail test client (LoadGen)

We began our testing by installing a fresh copy of Microsoft Windows Server 2003 R2, Enterprise x64 Edition Service Pack 2 on the test client. Before following these instructions, make sure to statically assign an IP address for the client, and then plug that port into the system under test. This allows the client to correctly join the domain. We followed this process for each installation:

1. Assign a computer name of Client_x for the mail client, where x is the client number.
2. For the licensing mode, use the default setting of five concurrent connections.
3. For the administrator log on, enter a password.
4. Select Eastern Time Zone.
5. Use typical settings for the Network installation.
6. Assign a name of Testbed for the workgroup.

To set up this server, we had to install several additional software components. The following subsections detail the necessary installation processes.

Joining the domain

1. Right-click My Computer, and select Properties.
2. Under the Computer Name tab, click Change.
3. In the Computer Name Changes window, under the Member of section, select the Domain radial box, and type test.
4. To start joining the domain, select OK.

5. When the window appears asking for a person qualified on the domain, type `Administrator` as the username and `Password1` as the password.
6. At the Welcome pop-up window and the window warning that you must reset the computer for the changes to take effect, click OK.
7. At the System Properties window, click OK.
8. When a pop-up window appears asking if you want to restart now, click Yes.

Installing Internet Information Services 6.0

1. Select Start→Control Panel→Add or Remove Programs.
2. Click Add/Remove Windows Components.
3. Select Application Servers, and click Details.
4. Click Active Directory Services, and make sure a check appears in the check box.
5. Select Internet Information Services (IIS), and click Details.
6. Click NNTP Services and SMTP Services, make sure a check appears in both check boxes, and click OK.
7. Click OK to close the Application Server window.
8. At the Windows Components Wizard, click Next to begin the installation.
9. When the system prompts you to do so, insert the OS CD, and click OK.
10. At the Completing the Windows Components Wizard window, click Finish.
11. Close the Add or Remove Programs window.

Installing Exchange Server 2007 and Load Generator

1. Insert the Microsoft Exchange Server 2007 CD. The CD should automatically launch the installation software.
2. Click the link to Step 1: Install .NET Framework 2.0.
3. When you arrive at the download link, download the x64 version of the .NET Framework, and install.
4. Click the link to Step 3: Install Microsoft Windows PowerShell to go to the download link.
5. When you arrive at the download link, download Microsoft Windows PowerShell, and install with defaults.
6. Search for and then download .NET 2.0 SP1 x64.
7. Install SP1 with all defaults.
8. Click the link to Step 4: Install Microsoft Exchange Server 2007 SP1.
9. Click Next to go past the introduction screen.
10. Accept the license agreement, and click Next.
11. Select No for error reporting, and click Next.
12. Select Custom Exchange Server Installation, and click Next.
13. Check Management Tools, and click Next.
14. After the check finishes, click Install to start the installation process.
15. Once the installation completes, click Finish.
16. Download and install Load Generator using all defaults.

Preparing Load Generator

1. Select Start→All Programs→Microsoft Exchange→Exchange Load Generator.
2. When the Load Generator window appears, select Start a new test.
3. Select Create a new test configuration, and click Continue.
4. In the Specify test settings window, type `Password1` as the Directory Access Password and Mailbox Account Master Password, and click Continue with recipient management.
5. Make 125 users in the Mailbox Database, and click Continue.
6. To accept defaults for Advanced recipient settings, click Continue.
7. In the Specify test user groups window, select the plus sign (+) to add a user group.
8. Change the Client Type to Outlook 2007 Cached and the Action Profile to Average, and click Continue.
9. Leave defaults in Remote configurations, and click Continue.
10. Click Save the configuration file as, and name it `Average.cfg`
11. Click Start the initialization phase (recommended before running the test) to start initialization. The initialization process might take a few hours.

Backing up the mail database

On the test server, once you have set up LoadGen and created its initial mail database, you need to back up that database so you can have clean copies for each test. Use this process to back up that database:

1. Select Start→All Programs→Microsoft Exchange Server 2007→Exchange Management Console in the mail server.
2. In the left pane, under Server Configuration, click Mailbox.
3. In the right pane, right-click Mailbox Database, and select Dismount Database from the menu.
4. On the Do you want to continue? pop-up message, click Yes.
5. Right-click Public Folder Database, and select Dismount Database from the menu.
6. On the Do you want to continue? pop-up message, click Yes. The red arrow appears when you have dismounted the Public Folder Store.
7. Using Windows Explorer, create two new folders: C:\backup\mailstore and C:\backup\publicstore.
8. With Windows Explorer, copy all files from C:\Program Files\Microsoft\Exchange Server\Mailbox\First Storage Group to C:\backup\mailstore, and all the files from C:\Program Files\Microsoft\Exchange Server\Mailbox\Second Storage Group to C:\backup\publicstore. This process may take several minutes.
9. Close Windows Explorer.
10. In Exchange Management Console, right-click Mailbox Database, and select Mount Database from the menu.
11. Right-click the Public Folder Database, and select Mount Database from the menu.
12. Close Exchange System Manager.

Disabling Windows Firewall

1. Click Start, and click Control Panel.
2. Double-click Windows Firewall.
3. Click Turn Windows Firewall on or off.
4. Select Off.
5. Click OK.

Creating the Public Folder Database

1. Click Start, and click Exchange Management Console.
2. Right-click First Storage Group.
3. Click New Public Folder Database.
4. For the Public Folder Database name, type Public Database.
5. Click Browse, navigate to F:\Loadgen, and click Save.
6. Click New.
7. Click Finish.

Changing the default Mailbox Database drive location

1. Click Start, and click Exchange Management Console.
2. Right-click Mailbox Database.
3. Select Move Database Path.
4. Click Browse, navigate to F:\Loadgen, and click Save.
5. Click Move.
6. When the application prompts you to dismount the mailbox database, click Yes.
7. Click Finish.

Creating and configuring the LoadGen tester user

1. Click Start, and click Administrative Tools.
2. Click Active Directory Users and Computers.
3. Expand anson.lan, and click Users.
4. Right-click the right pane, highlight New, and click User.
5. Select a name for the user, and type `tester` as the User logon name.
6. Click Next.
7. Type `Password1` for the password.
8. Uncheck User must change password at next logon, check Password never expires, and click Next.

9. Click Finish.
10. Right-click your newly created user, and select Properties.
11. Click the Member Of tab.
12. Click Add.
13. In Enter the object names to select, type `Domain Admins` and click Check Names.
14. Click OK.
15. Click Add again.
16. In Enter the object names to select, type `Exchange Organization Administrators` and click Check Names.
17. Click OK.
18. Click Add again.
19. In Enter the object names to select, type `Administrators` and click Check Names.
20. Click OK.
21. Click OK again.
22. Click Start, and click Exchange Management Console.
23. Expand Recipient Configuration, and click Mailbox.
24. At the right-pane menu, click New Mailbox...
25. Select User Mailbox, and click Next.
26. At the User Type screen select Existing users, and click Add...
27. Select your tester user, and click Next.
28. At the Mailbox settings screen, select Browse, choose the Mailbox Database, and click OK.
29. Click Next.
30. Click New.
31. Click Finish.

Running the test

To perform the test, we used a series of batch files. We stored batch files either under the `C:\ServerShare` folder on the server or under the `C:\ClientShare` folder on the clients. We use simple file sharing to copy files from machine to machine, as we needed.

We put batch files in the startup folder on the LoadGen and DVD Store clients. This way, when we rebooted the systems they would start a batch file, which ran a loop script waiting for the server to copy a file to the client. To begin, the test we executed a script on the server.

Between tests, we ran a restore script, which dismounted the Mailstore and Database and then restored them from backup. After the restore finished, the script rebooted the server and all clients.

Starting WebBench

1. Restart the Web Controller.
2. On the desktop, double-click the Web Controller shortcut.
3. Go to the top bar, and click Clients→Start Log In...
4. Restart all of the Web Clients.
5. Wait for all of the Web Clients to appear on the left side of the WebBench Controller Program.
6. Click OK.
7. When the application prompts you to add a test suite, click Yes.
8. Select `45minute_Anson 12 client ecommerce_api_template.tst`.
9. Give the run an appropriate name (e.g., `Anson_WB_Run1`).
10. Click OK.
11. When the Would you like to start executing the test suites? Screen appears, do not click Yes or No. Instead, leave the screen.

Starting LoadGen

1. Restart the Mail Client.
2. Leave the screen sitting when it boots up.

Starting DVD Store

We created a batch file to run the following parameters to begin the DVDStore test. ds2sqlserverdriver.exe --target=10.1.5.250 --ramp_rate=10 --run_time=42 --n_threads=125 --db_size_str=V --think_time=3 --database_name=DS2 --n_searches=10

1. Restart the DVD Store client.
2. Leave the screen sitting when it boots up.

Starting the test

1. Restart the system under test (SUT).
2. Let the SUT idle for 10 minutes.
3. Run c:\SBSbench_run1.cmd.
4. When the script tells you to, start WebBench.
5. LoadGen and DVD Store will begin automatically in the next 5/15 minutes, respectively.
6. Run the restore_all script between each run.

Network test bed configuration

To generate the workload, we used a network with 43 client PCs. We split 40 of the clients into four segments, or subnets, of 10 clients each. We configured these clients with Windows XP Professional with Service Pack 3. We connected each segment to the server under test via one NETGEAR GS724T Gigabit Smart Switch. To balance the load on the server and to prevent a network throughput bottleneck, we connected each segment to a separate network port. We used the remaining three clients for the WebBench controller, LoadGen client, and DVD Store client.

Measuring power

To record each solution's power consumption during each test, we used an Extech Instruments (www.extech.com) 380803 Power Analyzer/Datalogger. We connected the power cord from the server under test to the Power Analyzer's output load power outlet. We then plugged the power cord from the Power Analyzer's input voltage connection into a power outlet.

We used the Power Analyzer's Data Acquisition Software (version 2.11) to capture all recordings. We installed the software on a separate Intel processor-based PC, which we connected to the Power Analyzer via an RS-232 cable. We captured power consumption at one-second intervals.

To gauge the idle power usage, we recorded the power usage for 2 minutes while each system was running the operating system, but otherwise idle, meaning the system was not running any test workload. To ensure the system was idle, we allowed the system to sit for 10 minutes after booting to the desktop before starting the 2 minutes of idle power capture.

We then recorded the power usage (in watts) for each system during the testing at 1-second intervals. To compute the average power usage, we averaged the power usage during the time the system was producing its peak performance results. See Figure 10 (idle and workload power) for the results of these measurements.

Appendix A – Price information

Figure 12 provides the list price information for the test systems as of June 12, 2009. Prices exclude tax and shipping costs.

System	Dell PowerEdge T410	HP ProLiant ML150 G6
Price as of June 12, 2009	\$6,979.00	\$7,979.00

Figure 12: List price information for the test systems. Prices exclude tax and shipping costs.

Appendix B – Test system configuration information

Figure 13 provides detailed configuration information about each of the test server systems, which we list in alphabetical order.

Servers	Dell PowerEdge T410	HP ProLiant ML150 G6
General		
Number of processor packages	2	2
Number of cores per processor package	4	4
Number of hardware threads per core	2	2
System power management policy	Balanced	Balanced
Power Supplies		
Total number	2	2
Wattage of each (W)	580	750
Cooling Fans		
Total number	1	4 (HP requires the additional two-fan kit for system with two processors)
Dimensions (H x W) of each	4.75" x 1.75"	(1) 4.75" x 1.50"; (3) 3.65" x 2.00"
Voltage (V)	12	12
Amps	1.70 A	(1) 2.70 A; (3) 3.24 A
CPU		
Vendor	Intel	Intel
Name	Xeon E5540	Xeon E5540
Stepping	D0	D0
Socket type	LGA1366	LGA1366
Core frequency (GHz)	2.53	2.53
Front-side bus frequency	5.86 GT/s	5.86 GT/s
L1 cache	32 KB + 32 KB (per core)	32 KB + 32 KB (per core)
L2 cache	4 x 256 KB	4 x 256 KB
L3 cache (MB)	8	8
Platform		
Vendor and model number	Dell PowerEdge T410	HP ProLiant ML150 G6
Motherboard model number	0M638F	519728-001
Motherboard revision number	X02	0A
BIOS name and version	Dell BIOS 1.0.2	HP BIOS 021
BIOS settings	Default	Default
Memory module(s)		
Vendor and model number	Crucial CT51272BB1339	Crucial CT51272BB1339
Type	PC3-10600 DDR3	PC3-10600 DDR3
Speed (MHz)	1,333	1,333
Speed in the system currently running @ (MHz)	1,066	1,066
Timing/latency (tCL-tRCD-iRP-tRASmin)	8-8-8-19	8-8-8-19
Size (GB)	24	24
Number of RAM modules	6 x 4 GB	6 x 4 GB

Servers	Dell PowerEdge T410	HP ProLiant ML150 G6
Chip organization	Double-sided	Double-sided
Hard disk		
Vendor and model number	Dell ST3146356SS	HP DF0146B8052
Number of disks in system	6	6
Size (GB)	146	146
Buffer size (MB)	16	16
RPM	15,000	15,000
Type	SAS	SAS
Controller	Dell PERC6/I Controller	HP Smart Array P410/256 Controller
Controller driver	Dell 2.23.0.64 (7/1/2008)	HP 6.14.0.64 (1/7/2009)
Operating system		
Name	Microsoft Windows Server 2008 64x Enterprise Edition	Microsoft Windows Server 2008 64x Enterprise Edition
Build number	6001	6001
Service Pack	1	1
File system	NTFS	NTFS
Kernel	ACPI x64-based PC	ACPI x64-based PC
Language	English	English
Microsoft DirectX version	10	10
Graphics		
Vendor and model number	Matrox G200eW	Matrox G200e
Type	Integrated	Integrated
Memory size (MB)	8	8
Resolution	1,280 x 1,024	1,280 x 1,024
Driver	Microsoft 6.0.6001.18000 (6/21/2006)	Microsoft 6.0.6001.18000 (6/21/2006)
Network card/subsystem		
Vendor and model number	Broadcom BCM5716C NetXtreme II Adapter	HP NC107i Integrated PCI Express Gigabit Server Adapter
Type	Integrated	Integrated
Driver	Broadcom Corp. 4.8.5.0 (1/28/2009)	HP 12.0.0.6 (3/19/2009)
Additional network adapter	Intel PRO/1000 PT Quad Port Server Adapter	HP NC364T PCI Express Quad Port Gigabit Server Adapter
Type	PCI-Express	PCI-Express
Driver	Intel 9.12.36.0 (12/4/2008)	HP 9.12.30.1 (3/31/2009)
Optical drive		
Vendor and model number	TSSTcorp TS-H653F	LG GDR-H20N
Type	DVD-RW	DVD-ROM
USB ports		
Number of ports	6	6
Type of ports (USB 1.1, USB 2.0)	2.0	2.0

Figure 13: Detailed system configuration information for the two servers.

About Principled Technologies

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Our founders, Mark L. Van Name and Bill Catchings, have worked together in technology assessment for over 20 years. As journalists, they published over a thousand articles on a wide array of technology subjects. They created and led the Ziff-Davis Benchmark Operation, which developed such industry-standard benchmarks as Ziff Davis Media's Winstone and WebBench. They founded and led eTesting Labs, and after the acquisition of that company by Lionbridge Technologies were the head and CTO of VeriTest.



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